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U.S.-JAPAN COMPETITION IN SEMICONDUCTORS

Summary

The current debate over industrial policy has, to a large extent, been shaped by American manufacturers of semiconductors. They have long maintained that U.S. preeminence in the field is in jeopardy because of "an extensive, long-range program developed, orchestrated, and partially financed by the Japanese government to propel its semiconductor industry to world leadership." The effects of Japanese targeting have already shown up in the erosion of the domestic industry's competitiveness in one critical product -- computer memory chips, spokesmen assert. Without help from the U.S. government and changes in the way the Japanese industry operates, say representatives of the U.S. industry, American makers' international position in other key product lines could be undermined as well. Domestic makers have suffered reverses in memory products, but these setbacks are neither necessarily permanent nor the result of targeting, this report indicates.

Introduction

For the past five years, American manufacturers of semiconductors for the merchant market have been admonishing policymakers and legislators that the United States risks losing world leadership in integrated circuits and discrete devices to Japan unless Washington helps to reverse the odds. These warnings were underscored in February 1983 when the Semiconductor Industry Association (SIA) released The Effect of Government Targeting on World Semiconductor Competition: A Case History of Japanese Industrial Strategy and the Costs for America, a study purporting to document a decade-long effort by the Japanese government to catapult the domestic semiconductor industry into a position of technological preeminence.

In broadbrush terms, SIA's version of the competitive threat posed by Japan's semiconductor industry runs like this. Through government financial support, cartelization and domestic market protection, Japanese makers were able to achieve technological parity with their American rivals in the key product area of high-density dynamic random access memories (RAMs), the primary type of metal-oxide-silicon (MOS) memory chips. In the late 1970s, these companies launched a big export push in RAMs "characterized by an extremely rapid increase in the volume of devices sold and price reductions so steep that non-Japanese firms could not match them profitably." In quick order, this drive first netted Japanese vendors a major share of the world market for third-generation RAMs — 16-kilobit RAMs — and then landed them a dominant position in the 64K RAM marketplace. Hard hit by Japan's high-volume, low-price RAM export strategy, U.S. semiconductor manufacturers suffered large financial losses in both 1981 and 1982.

In the SIA scenario, the effect of an unchecked Japanese sales drive in memory chips is clear. "A commanding Japanese market share in dynamic RAMs will be translated quickly into higher production volume, corresponding cost advantages and an increasing technological edge as Japanese firms, building on this advantage, move on to take over other semiconductor product lines. At that point, U.S. firms will be in second place, and falling further behind."

At first glance, the SIA appears to be crying wolf. After all, American companies still supply roughly two-thirds of the worldwide semiconductor market — a market pegged at $14.6 billion in 1982, while their Japanese competitors have perhaps half that stake. Similarly, the share of Japan's apparent semiconductor consumption served by U.S. exporters is nearly double the 5-percent-plus part of American consumption filled by Japanese suppliers. Moreover, MOS memories account for less than one-fifth of worldwide semiconductor sales and RAMs make up only part of that market segment. Equally important, U.S. producers remain the technology and market leaders in cutting-edge microprocessors and the peripheral chips used with them, bipolar logic circuits, custom and semicustom chips, and non-RAM MOS devices like erasable programmable read-only memories (EPROMs).

Despite these facts, the U.S. semiconductor trade group maintains that there is real cause for alarm about U.S. leadership in semiconductors. High-volume RAMs, as one company executive noted, have traditionally been the American industry's "cash cows," providing the profits to finance ever-increasing research and development costs and capital spending requirements in this and other semiconductor product lines. "The recent Japanese high-density RAM success . . . threatens to break the cycle of 'investment/marketplace success/profits/reinvestment' that has propelled the U.S. industry to world leadership," the SIA argues in its white paper. In addition, U.S. manufacturers point out, the technology mastered in turning out RAMs can be transferred to almost every device in a company's product lineup, making a forced retreat from RAMs a double threat to American technological superiority. They insist as well that Japan's export push in high-density memories is not an isolated episode; it "represents an initial salvo in a competitive challenge to the U.S. semiconductor industry similar to those which Japan has mounted in other key industries."

This report will look at U.S.-Japan competition in the American market for 16K and 64K RAMs, as well as where the two industries stand in the upcoming battle for leadership in the next-generation RAM market. It will also touch on the political response of domestic manufacturers to the inroads of the Japanese challengers. This study builds on an earlier three-part series (see Council Report No. 41, December 7, 1979;

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No. 4, January 24, 1980; and No. 9, March 7, 1980) that covered production and trade trends in the U.S. and Japanese industries, their structure and domestic markets, comparative capital investment and research and development, and market-access problems in Japan.

Japanese Gain Market Foothold

U.S. semiconductor makers have to shoulder a large part of the responsibility for letting their Japanese rivals get a foothold in the American MOS memory market. When semiconductor orders hit the skids during the 1975 recession, the industry slashed capital spending, cutting it in half according to some estimates. Companies also pared their work forces quickly and deeply. Japanese manufacturers, in contrast, continued to add capacity and invest in new equipment over the course of the recession, with an eye on remaining competitive in the computer, telecommunications and other end-equipment markets they supply as vertically integrated producers.

Semiconductor shipments in the United States roared back from the recession in 1976 and gathered more steam the next year, spurred partly by initial volume production of 16K RAMs for the merchant market. Computer industry demand for the new memory chip took off in 1978 when it reached price-per-bit equivalency with the 4K RAM. Moreover, International Business Machines Corp. unexpectedly entered the merchant market with substantial requirements for 16K RAMs to make up for shortfalls in in-house production of 64K RAMs earmarked for its new generation of medium-capacity mainframes. With U.S. 16K RAM demand expanding so rapidly, inadequate domestic production capacity soon became a major bottleneck. Nippon Electric Co., Ltd., Japan's top semiconductor maker, and number-two Hitachi, Ltd. quickly jumped into the gap. In short order, they plus Fujitsu, Ltd. captured 36 percent of the U.S. 16K merchant market — a stake that expanded to a 42-percent share in 1979.

The loss of that much of the high-volume RAM market was bad enough, but what really angered 16K RAM production leader Mostek Corp. and other leading merchant MOS memory makers like Motorola Inc., Intel Corp. and National Semiconductor Corp. were the alleged pricing policies of their Japanese competitors. In late 1977, when NEC and Hitachi were just moving into the U.S. memory market, 16K RAM prices were running between $16 and $18, with expectations that late 1978 prices would be around $10 a chip; instead, prices fell to about $6. To some SIA members, this drop smacked of predatory pricing by Japanese exporters, which were said to be not only setting their prices 20 to 30 percent below American vendors but also dumping to win market share.

With falling prices pushing demand up in 1979, a number of early U.S. 16K RAM market entrants brought additional capacity onstream and several American latecomers started turning out the memory chip. This new capacity moved into volume production in early 1980 — just as IBM, the biggest 16K RAM buyer, scaled back its purchasing plans for the year and several other American computer makers cancelled some of their orders. Prices, which had stabilized at roughly $6 in 1979 because of excess demand, abruptly began to slide, hitting about $3.50 at midyear.

The worst was yet to come. Orders for 16K RAMs slowed in the second half of 1980 as the recession started to trim the rapid growth of the data-processing industry and other end-user markets, and demand continued to fall far short of worldwide capacity into 1981. Anxious, however, to recover their equipment and R&D costs, American makers, particularly the latecomers, pumped out an increasing number of chips; so, to a lesser extent, did Japanese manufacturers. The result was predestined: 16K RAM prices collapsed in the first part of 1981.

While producers in Japan and at least one leading U.S. memory supplier began to pull back from the market after midyear, most domestic makers rode with the 16K RAM, hoping that rockbottom prices would spur demand. They did. U.S. shipments soared in 1981's third quarter and then flattened out at near-record levels for the rest of that year and 1982. But the decision to stick with the price-eroded 16K RAM proved to be a costly one for American companies. According to the SIA's report, Mostek, Motorola, Intel, National Semiconductor and Advanced Micro Devices Inc. ran up a $39.9-million loss on their 16K RAM operations in the first nine months of 1982 on top of a net loss of $26.5 million in 1981. The association, of course, attributes this red ink to Japanese pricing practices rather than to the cutthroat competition among these five makers and other U.S. vendors to extend the life of the 16K RAM.

Battleground Moves to the 64K RAM Market

With one major exception, U.S. merchant MOS memory makers had no choice but to stick with the price-eroded 16K RAM. They had not planned it that way. Seven months after Fujitsu's February 1978 introduction of the first 64K RAM for the merchant market, Texas Instruments Inc., historically the number-one U.S. semiconductor maker, announced its own version. In quick succession, Mostek and Motorola unveiled plans to produce the new-generation memory chip. During 1980, other American companies, including Intel, National Semiconductor and Fairchild Camera and Instrument Corp. began readying sample 64K RAMs for evaluation by major computer manufacturers and other big original equipment manufacturers.

The 64K RAM proved to be much more difficult to design and manufacture than American semiconductor firms had anticipated. Companies like Mostek and National Semiconductor, which opted to advance the state of the art with an eye on perfecting technologies applicable to the production of future generations of RAMs as well as the 64K RAM, ran into formidable manufacturing problems. Final yields — the number of usable chips per wafer processed -- were said by outside observers to vary from a mere 5 percent down to no usable chips. Even some makers that decided to finetune the product and process technologies they had used to manufacture 16K RAMs had trouble obtaining acceptable yields in volume production. Intel, for example, had to pull its original 64K product from the market in late 1980 and start over. Texas Instruments, too, hit manufacturing roadblocks that put its market entry at least a year behind schedule. Only Motorola was able to deliver 64K RAMS at an early date, apparently because it committed money to the chip before others did.

By late 1981, U.S. semiconductor industry analysts were starting to write American companies off as nothing more than supporting players in the merchant 64K RAM market. At that time Motorola and Texas Instruments were the lone U.S. merchant makers offering the circuit in production quantities. Arrayed against them were six Japanese manufacturers — Hitachi, Fujitsu, NEC, Mitsubishi Electric Corp., Oki Electric Industry Co., Ltd. and Toshiba Corp. These companies managed to sidestep the problems that delayed volume 64K RAM production at Mostek, National Semiconductor and Intel, primarily by modifying and refining the design and manufacturing technologies incorporated in their 16K products. This strategy, which led to acceptable yields early on, gave Japanese vendors 60 percent of the worldwide merchant market in 1980 and a 70-percent stake in the 1981 market, including one-half to two-thirds of U.S. sales in those two years.

Early market dominance by Japanese suppliers was not as ominous for American companies as it first appeared. Worldwide 64K RAM shipments added up to only 441,000 units in 1980, primarily for vendor qualification, and 1981 shipments, while totaling 12

million circuits, were dwarfed by 16K RAM sales of perhaps 215 million units that year. The 64K RAM market, in short, developed very gradually, far more slowly than the markets for earlier generations of RAMs. This reduced or even eliminated the penalty for being late.

The reason the market emerged so slowly is not hard to find. With 16K prices sliding through 1980 and then collapsing in early 1981, manufacturers, whether Japanese or American, thought twice about expanding production of 64K RAMs, afraid that plummeting 16K prices would pull down 64K prices and rob them of the chance to recoup development costs. For their part, computer makers had no incentive to buy 64K RAMs, given the prices of 16K RAMs. To be competitive, 64K RAMs could be priced only four times more than their predecessors, plus a premium for the technical advantages of greater density. No bargain before 16K RAM prices collapsed, 64K RAMs, priced in early 1981 at about $20 a circuit for volume orders, were no more attractive after 16Ks started selling for $1.50 and under.

Prices for the new chip finally started moving toward what users considered acceptable levels in 1981's second half as Japanese makers, followed in lock step by Motorola and Texas Instruments, gradually began to put more 64K RAM capacity in operation. By year-end, 64K prices crossed over into the bargain range and the market took off with a roar. Price quotes, however, continued to come down through the first quarter of 1982 before firming at the $5.50-to-$6 level for high-speed devices in volume. Why prices firmed is the subject of much controversy. Hitachi and Fujitsu, then the two major Japanese players in the U.S. market, maintained that demand in the United States and at home was increasing faster than they could increase production. Some American semiconductor executives and industry watchers charged instead that Japanese exporters were deliberately holding back U.S-bound shipments to mute a rising chorus of complaints about dumping. (This interpretation received an unexpected boost from the Justice Department, which launched a restraint-of-trade inquiry into Japanese sales in mid-1982 — see JEI Report No. 30B, August 6, 1982.) Motorola was particularly outspoken about Japanese pricing practices, claiming that its competitors were intentionally dropping prices quicker than costs were coming down in an effort to buy market share.

The emergence of a buyer's market in the spring of 1982 dampened talk about dumping. It also gave American latecomers to the 64K RAM market the reprieve they needed. Mostek moved into volume production early in the year, while Intel started turning out commercial quantities of its redesigned chip part way through 1982, followed later by Fairchild. National Semiconductor, alone among the major U.S. companies to announce early availability of 64K RAMs, failed to get on board because of insurmountable yield problems with its new technology. (These problems, well-publicized, plus the start-up troubles that delayed Mostek's and Intel's market entry, undercut SIA's attempt to link losses of $30.5 million in 1981 and $46.6 million in 1982 on the 64K RAM operations of its sample companies to Japanese pricing policies.)

With the newcomers gearing up production in 1982 and established suppliers bringing additional capacity onstream, 64K RAM prices again came under pressure during the latter part of the year, despite what seemed to be recession-proof demand from small computer and mainframe manufacturers in both countries. This past spring, however, the market underwent another of its periodic flip-flops. The U.S. personal computer industry's appetite for memory, already voracious, became virtually insatiable. In Japan, too, demand for 64K RAMs exploded, both in-house from the companies' computer divisions and outside. Lead times for delivery in the United States, which had been running approximately six to eight weeks at the start of 1983, stretched to about three or four months in March for top suppliers and then to roughly six months in June. More importantly for memory manufacturers, prices on volume orders for high-speed 64K RAMs rose from under $4 in April to above $5 at midyear.

With prices firming and then turning up this year, the 64K RAM finally became a consistently profitable item for suppliers, U.S. industry analysts say. MOS memory makers in the United States as well as in Japan will need to wring all the money they can from the chip to underwrite the huge ($50 to $100 million minimum per company) R&D and equipment costs of the next RAM generation, the 256K. So far at least, the leading U.S. merchant memory makers seem to have come up with the funds needed to bring the new circuit to the market, despite profit margins eroded by declining memory prices and recession-dampened demand for some other semiconductor products.

In fact, overall semiconductor R&D and capital spending in the United States has been unusually strong in recent years, even during the recession. Plant and equipment expenditures, for example, rose sharply during the late 1970s and then jumped in 1980. Determined not to repeat the mistake they made during the 1975 slump, U.S. semiconductor makers maintained 1980's high level of capital investment through 1981. They had hoped to duplicate this feat again last year, but weak prices and the recession dashed these plans. Still, capital spending was off only modestly — perhaps 10 percent — from the 1980-81 peak.

Aside from worrying about financing escalating equipment and development requirements out of weak profits, U.S. semiconductor makers were looking nervously over their shoulders at what their Japanese rivals were doing. What they saw was disquieting. Like American firms, Japanese manufacturers significantly expanded capital spending during the late 1970s, and they continued to do so in both 1981 and 1982. By fiscal 1982 (April 1982-March 1983), as a result, investment in yen terms was almost three times higher than five years before. Equally frightening to U.S. companies, Japanese semiconductor producers spent almost as much on plant and equipment in FY 1982 as American merchant makers did last year. Moreover, the six firms that compete in the world MOS memory market invested the equivalent of 20.3 percent of their overall sales in plant and equipment in FY 1982, compared with 13.7 percent in FY 1978, while capital spending by leading U.S. merchant companies averaged an estimated 15 percent of sales last year, down two points from 1981.

The 256K RAM: Replay of the 64K Battle or a New Ballgame?

Depending on which industry analyst one listens to, Japanese manufacturers of memory chips will be unable to repeat their 64K RAM success in the emerging market for 256K RAMs because of the design strategy they adopted for the present-generation product or, alternatively, American companies, unwilling or unable to risk a replay of the 64K RAM debacle, will not even be at the starting gate for the upcoming race. Neither scenario pans out at the present time.

Analysts pushing the first scenario argue that Japanese semiconductor companies will be at a competitive disadvantage in the 256K RAM market because they will have to go back to their design rooms and come up with new product and process technologies suitable to the denser chip and then iron out manufacturing problems. Japanese manufacturers, in short, will have to do what Mostek and other U.S. memory makers did with the 64K RAM. The drawback of this line of reasoning is that it ignores the fact that Japanese producers started work on alternative 256K RAM technologies several years ago. These technologies, some quite novel, are showing up in the samples that Fujitsu, NEC and other Japanese suppliers are now shipping to customers. Of course, it is too soon to know whether the new designs and processes will work in volume production, but American companies will not necessarily make a problem-free switch to volume production of the 256K RAM just because they use the same or similar technologies to turn out 64K RAMs.

It is also too soon to count U.S. memory makers out of the 256K race, as the second scenario suggests. So far at least, there have been no official dropouts. On the contrary, Mostek says it plans to ship 256K RAMs "for revenue" this year, while Motorola and Texas Instruments are expected to start sampling this quarter, followed in the fourth quarter by Intel. In addition, National Semiconductor, which maintains that it has licked the manufacturing problems that kept it out of the 64K RAM market, plans to ship out samples in 1984's first half. Advanced Micro Devices also says it will jump back into the high-density RAM market, starting with a fast 64K device this year and a 256K counterpart in 1985.

The 256K product announcement that is causing the biggest stir in the industry, though, comes not from existing suppliers but from Western Electric Co., Inc. American Telephone and Telegraph Co.'s manufacturing arm revealed this past spring that the first product it will offer in its initial foray into the merchant semiconductor market is a 256K RAM. The company, which is already manufacturing the device in commercial quantities for in-house use, is presently sending samples to potential outside customers. Volume production for the merchant market is scheduled to start this summer, with shipments beginning later in the year.

Western Electric's planned timetable could resolve the major dilemma facing current merchant market participants: when to ramp up production of 256Ks. Up to now, vendors have been afraid that early volume availability of the next-generation chip would pull down 64K prices just when the part is finally starting to make money for them. At the same time, manufacturers insist they will not hold the 256K RAM back to extend the life of the 64K RAM.

Even if semiconductor companies do go ahead with volume 256K output later this year, the market for the new circuit is not expected to take off until 1986 when it reaches price-per-bit equivalency with the 64K RAM. Until then, it is too risky to bet whether Japanese makers will repeat their 64K RAM success, including their capture of a 70-percent worldwide market share again in 1982, or whether American suppliers will regain control of the memory market.

SIA Keeps Up the Pressure

Although the semiconductor business is once again booming, providing merchant makers with a needed influx of money for R&D and new plant and equipment, the Semiconductor Industry Association has not abandoned its five-year-old political campaign. Member companies continue to lobby the White House and Capitol Hill for changes in U.S. tax policy, particularly with respect to equipment write-offs and R&D credits, to offset part of the unfair competitive edge they believe their Japanese rivals receive through government financial assistance. They also continue to press the Reagan administration for retaliatory action against the effects of Japanese government targeting policies.

The initial focus of this effort was the "buy-in" pricing of Japanese semiconductor exporters in the American 64K RAM market. This angle has been quietly dropped, replaced by a new bid for action to improve the access of U.S. suppliers to the semiconductor market in Japan. So far, however, the SIA has been unwilling to take the final plunge and file a complaint under Section 301 of the 1974 Trade Act.

Twice this year, the group's board of directors has backed away from the brink. The first time, in February, the board, after failing to reach internal agreement on going the trade-complaint route, said it preferred to give the Reagan administration more time

to resolve the market-access issue through bilateral negotiations. In pulling back again in mid-July, board members cited the "favorable results" of recent discussions between U.S. government trade officials and their Japanese counterparts. During these talks, held under the auspices of the U.S.-Japan Work Group on High-Technology Industries (see JEI Report No. 43B, November 5, 1982), the Japanese side agreed to participate in a program to monitor merchant sales of semiconductors. It also promised to develop "concrete measures" to open the domestic market to American semiconductor suppliers.

For further information, contact Susan MacKnight.

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Table 1: U.S. Apparent Domestic Consumption of Semiconductors, 1978-82

(in thousands of dollars)

	1978	1979	1980	1981	1982
Total Shipments	$5,511,356	$7,200,640	$9,088,862	$9,634,560	n.a.
Total Exports	1,933,186	2,609,036	3,446,692	3,579,131	3,797,368
Total Imports	1,766,266	2,417,608	3,309,760	3,559,670	4,127,661
Trade Balance	166,920	191,428	136,932	19,461	-330,293
Apparent Domestic Consumption	5,344,436	7,009,212	8,951,930	9,615,099	n.a.
Exports as Percent of Apparent Domestic Consumption	36.2%	37.2%	38.5%	37.2%	n.a.
Imports as Percent of Apparent Domestic Consumption	33.1%	34.5%	37.0%	37.0%	n.a.
Exports to Japan as Percent of Apparent Domestic Consumption	2.0%	2.5%	1.7%	1.8%	n.a.
Imports from Japan as Percent of Apparent Domestic Consumption	2.5%	3.5%	4.4%	4.0%	n.a.

Source: Derived from following tables.

Table 2: Japan's Apparent Domestic Consumption of Semiconductors, 1978-82*

(in thousands of dollars)

	1978	1979	1980	1981	1982
Total Production	$2,531,469	$2,906,151	$3,810,509	$4,838,714	$4,796,507
Total Exports	476,805	760,274	1,084,366	1,242,041	1,430,738
Total Imports	385,206	572,730	615,155	696,575	649,982
Trade Balance	91,599	187,544	469,211	545,466	780,756
Apparent Domestic Consumption	2,439,870	2,718,607	3,341,298	4,293,248	4,015,751
Exports as Percent of Apparent Domestic Consumption	19.5%	28.0%	32.5%	28.9%	35.6%
Imports as Percent of Apparent Domestic Consumption	15.8%	21.1%	18.4%	16.2%	19.4%
Exports to the United States as Percent of Apparent Domestic Consumption	4.7%	8.8%	10.9%	9.1%	13.5%
Imports from the United States as Percent of Apparent Domestic Consumption	9.1%	14.0%	10.3%	8.4%	9.2%

*Neither Japan's production data nor its trade data include parts.

Source: Derived from following tables.

Table 3: U.S. Shipments of Semiconductors, 1978-81

(in thousands of dollars)

	1978	1979	1980	1981(p)
Integrated Circuits	$3,537,763	$4,716,580	$6,605,666	$6,764,450
Linear	406,036	463,028	685,442	799,858
Digital Bipolar	1,153,318	1,529,858	2,053,370	1,962,852
Microprocessors	19,123	36,999	57,212	61,080
Transistor-Transistor Logic	550,876	926,140	1,286,449	1,059,607
Other	583,319	566,719	709,709	842,165
Digital MOS	1,536,687	2,127,902	3,188,474	3,274,654
Microprocessors	269,145	485,709	754,847	754,081
Logic	322,498	398,357	622,879	816,332
Memory	945,044	1,243,836	1,810,748	1,704,241
Hybrid	441,722	595,792	678,380	727,086
Discrete Devices	1,289,768	1,542,718	1,608,867	1,828,480
Transistors	507,902	571,343	599,673	674,798
Diodes and Rectifiers	439,367	499,569	490,114	527,752
Other	342,499	471,806	519,080	625,930
Parts	683,825	941,342	874,329	1,041,630
Total Shipments	5,511,356	7,200,640	9,088,862	9,634,560

Source: U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports: Selected Electronic and Associated Products, Including Telephone and Telegraph Apparatus (MA-36N)

Table 4A: Total U.S. Exports of Semiconductors, 1978-82

(in thousands of dollars)

	1978	1979	1980	1981	1982
Integrated Circuits	$471,932	$650,056	$833,476	$768,410	$836,261
Linear	88,648	111,285	130,185	110,465	113,228
Digital Bipolar	79,106	99,499	137,656	128,505	133,320
Logic	n.a.	n.a.	n.a.	104,549	97,501
Memory	n.a.	n.a.	n.a.	23,956	35,819
Digital MOS	220,762	318,667	404,790	352,201	413,265
Microprocessors	n.a.	n.a.	n.a.	78,355	91,749
Logic	n.a.	n.a.	n.a.	92,226	131,571
Memory	n.a.	n.a.	n.a.	181,620	189,945
RAMs	n.a.	n.a.	n.a.	75,234	95,346
Other Monolithic	25,299	47,012	58,464	80,566	104,408
Hybrid	58,117	73,593	102,381	96,673	72,040
Discrete Devices	205,305	223,327	245,532	227,343	215,885
Transistors	85,374	90,880	95,217	87,339	81,764
Diodes and Rectifiers	69,053	75,761	88,675	79,579	74,244
Other	50,878	56,686	61,640	60,425	59,877
Parts	1,255,949	1,735,653	2,367,684	2,583,378	2,745,222
Total Exports	1,933,186	2,609,036	3,446,692	3,579,131	3,797,368

Table 4B: U.S. Exports of Semiconductors to Japan, 1978-82

(in thousands of dollars)

	1978	1979	1980	1981	1982
Integrated Circuits	$79,081	$138,290	$113,090	$119,420	$142,669
Linear	15,056	21,914	19,505	19,750	18,081
Digital Bipolar	19,553	28,579	24,085	24,739	26,265
Logic	n.a.	n.a.	n.a.	19,929	18,102
Memory	n.a.	n.a.	n.a.	4,810	8,163
Digital MOS	34,374	64,345	53,234	56,556	75,208
Microprocessors	n.a.	n.a.	n.a.	17,395	16,011
Logic	n.a.	n.a.	n.a.	14,785	23,526
Memory	n.a.	n.a.	n.a.	24,376	35,671
RAMs	n.a.	n.a.	n.a.	7,739	7,139
Other Monolithic	1,770	11,559	3,485	4,225	4,035
Hybrid	8,328	11,893	12,781	14,150	19,080
Discrete Devices	12,738	13,669	12,691	14,266	13,720
Transistors	6,657	5,399	4,295	6,438	6,408
Diodes and Rectifiers	3,000	4,169	4,030	4,228	3,666
Other	3,081	4,101	4,366	3,600	3,646
Parts	13,781	20,248	25,678	35,175	33,971
Exports to Japan	105,600	172,207	151,459	168,861	190,360

Source: U.S. Department of Commerce, U.S. Exports (FT 410)

Table 5A: Total U.S. Imports of Semiconductors, 1978-82

(in thousands of dollars)

	1978	1979	1980	1981	1982
Integrated Circuits	$1,388,588	$1,919,583	$2,756,516	$2,952,651	$3,461,331
Linear	185,112	223,886	286,711	324,573	388,107
Digital Bipolar	439,374	553,034	720,634	693,300	846,904
Logic	n.a.	n.a.	n.a.	455,358	614,683
Memory	n.a.	n.a.	n.a.	237,942	232,221
Digital MOS	619,872	941,183	1,615,353	1,813,617	2,084,522
Microprocessors	n.a.	n.a.	n.a.	242,085	267,615
Logic	n.a.	n.a.	n.a.	349,752	442,529
Memory	n.a.	n.a.	n.a.	1,221,780	1,374,378
RAMs	n.a.	n.a.	n.a.	712,282	834,359
Other Monolithic	52,411	82,299	28,926	19,290	45,696
Hybrid	91,819	119,181	104,892	101,871	96,102
Discrete Devices	302,980	352,267	370,185	438,344	433,816
Transistors	176,285	192,084	208,989	259,510	259,661
Diodes and Rectifiers	72,224	98,599	86,365	108,610	112,479
Other	54,471	61,584	74,831	70,224	61,676
Parts	74,698	145,758	183,059	168,675	232,514
Total Imports	1,766,266	2,417,608	3,309,760	3,559,670	4,127,661

Table 5B: U.S. Imports of Semiconductors from Japan, 1978-82

(in thousands of dollars)

	1978	1979	1980	1981	1982
Integrated Circuits	$82,694	$176,054	$314,341	$286,176	$444,967
Linear	9,786	1,583	13,845	15,257	22,397
Digital Bipolar	13,749	31,649	47,535	59,917	70,874
Logic	n.a.	n.a.	n.a.	28,474	40,753
Memory	n.a.	n.a.	n.a.	31,443	30,121
Digital MOS	18,529	67,990	231,404	190,773	328,968
Microprocessors	n.a.	n.a.	n.a.	5,394	9,279
Logic	n.a.	n.a.	n.a.	20,935	34,036
Memory	n.a.	n.a.	n.a.	164,444	285,653
RAMs	n.a.	n.a.	n.a.	128,763	215,950
Other Monolithic	1,961	3,374	713	2,178	1,516
Hybrid	38,669	71,458	20,844	18,051	21,212
Discrete Devices	40,007	45,419	42,633	54,731	57,646
Transistors	20,522	23,761	21,053	30,679	37,736
Diodes and Rectifiers	13,604	15,699	13,027	16,429	12,530
Other	5,881	5,959	8,553	7,623	7,380
Parts	11,352	20,533	40,247	44,464	80,994
Imports from Japan	134,053	242,006	397,221	385,371	583,607

Source: U.S. Department of Commerce, U.S. Imports for Consumption and General Imports (FT 246)

Table 6: Japan's Production of Semiconductors, 1978-82

(value in thousands of dollars*; quantity in thousands of units)

	1978	1979	1980	1981	1982
Value					
Integrated Circuits	$1,337,481	$1,747,408	$2,514,862	$3,123,034	$3,352,271
Linear	376,017	437,045	588,035	851,660	708,019
For Industrial Equipment	n.a.	n.a.	n.a.	n.a.	167,745
For Consumer Goods	n.a.	n.a.	n.a.	n.a.	540,273
Digital Bipolar	194,487	233,189	320,309	427,514	523,963
Logic	n.a.	n.a.	n.a.	n.a.	418,518
Memory	n.a.	n.a.	n.a.	n.a.	105,445
Digital MOS	625,741	895,898	1,365,632	1,541,018	1,753,246
Logic	n.a.	n.a.	n.a.	n.a.	835,884
Memory	n.a.	n.a.	n.a.	n.a.	917,362
Hybrid	141,236	181,277	240,886	302,843	367,043
Discrete Devices	1,193,988	1,158,743	1,295,647	1,715,680	1,444,236
Diodes	156,706	154,495	189,733	267,208	206,790
Rectifiers	235,680	226,120	232,322	263,367	210,464
Transistors	550,580	476,618	501,804	708,198	576,017
Light-Emitting Diodes	102,628	150,164	207,228	289,313	274,608
Other	148,394	151,346	164,560	187,594	176,358
Total Production	2,531,469	2,906,151	3,810,509	4,838,714	4,796,507
Quantity					
Integrated Circuits	1,176,152	1,777,376	2,660,172	3,495,157	4,381,077
Linear	608,082	849,648	1,164,407	1,557,920	1,640,802
For Industrial Equipment	n.a.	n.a.	n.a.	n.a.	376,716
For Consumer Goods	n.a.	n.a.	n.a.	n.a.	1,264,086
Digital Bipolar	261,541	367,411	514,592	613,842	963,244
Logic	n.a.	n.a.	n.a.	n.a.	934,791
Memory	n.a.	n.a.	n.a.	n.a.	28,453
Digital MOS	250,404	477,286	863,991	1,162,603	1,558,489
Logic	n.a.	n.a.	n.a.	n.a.	1,021,072
Memory	n.a.	n.a.	n.a.	n.a.	537,417
Hybrid	56,125	83,031	117,182	160,792	218,542
Discrete Devices	10,566,619	12,281,343	16,327,963	22,661,019	21,555,291
Diodes	3,605,354	4,489,182	6,424,432	8,817,839	7,980,714
Rectifiers	1,620,296	1,863,113	2,209,898	2,519,192	2,408,362
Transistors	4,077,159	4,305,932	5,527,623	8,698,034	8,371,872
Light-Emitting Diodes	555,211	940,410	1,410,805	1,841,574	2,113,487
Other	708,599	682,706	755,205	784,380	680,856

*The following average annual exchange rates, which reflect the midpoint on the Tokyo spot foreign exchange market, were used to convert the yen production figures: 1978, ¥210.40; 1979, ¥219.14; 1980, ¥226.75; 1981, ¥220.54; and 1982, ¥249.05.

Source: Japan, Ministry of International Trade and Industry, Yearbook of Machinery Statistics 1982

Table 7A: Japan's Total Exports of Semiconductors, 1978-82

(in thousands of dollars*)

	1978	1979	1980	1981	1982
Integrated Circuits	$246,115	$497,991	$805,140	$907,867	$1,148,119
Packaged	202,831	404,570	665,448	717,509	900,695
Unpackaged	43,284	93,421	139,691	190,357	247,424
Discrete Devices	230,691	262,283	279,226	334,175	282,619
Packaged	204,145	228,861	239,064	276,335	238,693
Transistors	107,204	108,550	101,780	111,043	87,789
Diodes and Rectifiers	61,425	73,687	77,360	86,480	65,545
Other	35,516	46,624	59,924	78,812	85,359
Unpackaged	26,546	33,882	40,162	57,840	43,926
Total Exports	476,805	760,274	1,084,366	1,242,041	1,430,738

Table 7B: Japan's Exports of Semiconductors to the United States, 1978-82

(in thousands of dollars*)

	1978	1979	1980	1981	1982
Integrated Circuits	$81,952	$192,388	$317,833	$323,675	$470,179
Packaged	81,242	188,757	307,432	306,688	442,528
Unpackaged	709	3,631	10,401	16,988	27,652
Discrete Devices	32,741	46,017	46,668	67,750	71,461
Packaged	31,399	44,307	44,069	64,548	68,130
Transistors	17,444	19,888	18,027	23,023	22,795
Diodes and Rectifiers	10,039	16,714	13,604	16,841	13,775
Other	3,915	7,705	12,438	24,683	31,561
Unpackaged	1,342	1,710	2,598	3,202	3,331
Exports to the United States	114,693	238,405	364,501	391,425	541,640

*The following average annual exchange rates, calculated by the Ministry of Finance, were used to convert the yen export figures: 1978, ¥212.18; 1979, ¥217.47; 1980, ¥227.67; 1981, ¥219.90; and 1982, ¥248.33.

Source: Japan, Ministry of Finance, Japan Exports and Imports: Commodity by Country

Table 8A: Japan's Total Imports of Semiconductors, 1978-82

(in thousands of dollars*)

	1978	1979	1980	1981	1982
Integrated Circuits	$288,936	$452,796	$477,775	$519,474	$513,015
Packaged	254,888	408,596	412,932	448,281	442,506
Digital	177,544	293,292	283,457	286,466	296,523
Other	77,344	115,303	129,475	161,815	145,983
Unpackaged	34,047	44,200	64,842	71,193	70,509
Discrete Devices	96,270	119,935	137,381	177,101	136,966
Packaged	95,996	119,114	136,558	176,638	136,387
Transistors	47,534	53,763	61,194	90,995	66,186
Diodes and Rectifiers	13,896	19,269	23,725	31,488	24,191
Other	34,566	46,083	51,639	54,155	46,010
Unpackaged	274	821	822	463	579
Total Imports	385,206	572,730	615,155	696,575	649,982

Table 8B: Japan's Imports of Semiconductors from the United States, 1978-82

(in thousands of dollars*)

	1978	1979	1980	1981	1982
Integrated Circuits	$191,793	$340,565	$305,320	$320,487	$336,263
Packaged	180,590	314,133	267,250	275,377	287,349
Digital	136,479	241,437	197,594	201,458	224,310
Other	44,111	72,697	69,656	73,919	63,039
Unpackaged	11,203	26,432	38,070	45,110	48,914
Discrete Devices	29,163	39,510	39,622	39,173	34,919
Packaged	28,905	38,724	38,915	38,797	34,512
Transistors	6,808	9,187	8,425	9,688	8,465
Diodes and Rectifiers	2,792	4,144	6,150	7,319	5,625
Other	19,304	25,393	24,340	21,790	20,422
Unpackaged	258	786	708	375	407
Imports from the United States	220,955	380,076	344,943	359,660	371,182

*The following average annual exchange rates, calculated by the Ministry of Finance, were used to convert the yen import figures: 1978, ¥212.17; 1979, ¥217.46; 1980, ¥227.85; 1981, ¥219.94; and 1982, ¥248.30.

Source: Japan, Ministry of Finance, Japan Exports and Imports: Commodity by Country